

high rate. In these cases, identifying locations downhill of the erosion area as a soil accumulation area may be the best alternative. These areas should be located as far away from the lake as possible.



Figures 49 and 50. Sediment erosion areas identified within Griffy Lake Nature Preserve, May and September, 2007.

6.5.5 Recommendations

As previously detailed, recommendations for addressing property-wide and shoreline erosion at Griffy Lake Nature Preserve are dependent upon the location and erosion issues present at the specific site. General recommendations are detailed above to address streambed and bank erosion and shoreline erosion. However, without specific site information, including elevation and grading information, specific on-site recommendations cannot be generated. Therefore, it is recommended that the Bloomington Parks and Recreation Department use grant monies through the IDNR's Lake and River Enhancement (LARE) Program to complete a feasibility/design study to address both streambed and bank erosion within the streams draining to Griffy Lake and the shoreline erosion issues along Griffy Lake's shoreline.

7.0 GRIFFY LAKE INVENTORY

7.1 Mercury Assessment

In the 2007 Fish Consumption Advisory (FCA) for Indiana (ISDH et al. 2007), Griffy Lake largemouth bass greater than 11 inches in size are listed under Advisory Group 3 for mercury (Table 6). This means that adult males and females should eat no more than one meal of these fish per month. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 should not eat any of these fish.

Table 6. Advisory Groups of the Indiana Fish Consumption Advisory.

Group	Advisory Level
Group 1	Unrestricted consumption. One meal per week for women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15.
Group 2	Limit to one meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15.
Group 3	Limit to one meal per month (12 meals per year) for adult males and females. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 (DO NOT EAT).
Group 4	Limit to one meal every 2 months (6 meals per year) for adult males and females. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 (DO NOT EAT).
Group 5	No consumption (DO NOT EAT).

Source: ISDH et al. 2007

In 1996, the Indiana State Department of Health (ISDH) discontinued its use of the FDA Action Level for mercury in fish (1.0 ppm) and went to a risk-based approach for safe consumption of fish. This is a sliding scale of consumption rates based on the level of contaminants found in the fish. The quantitative health risk assessment for a non-carcinogen, such as mercury, relies on a reference dose (RfD). This is an estimate of a daily exposure to the human population that is likely to be without an appreciable risk of deleterious health effects during a lifetime. This estimate is based on an uncertainty value which can span several orders of magnitude and several subgroups including men, women, pregnant women, and children (EPA, 2001).

The Indiana FCA makes the assumption that one-half pound of uncooked fish constitutes a standard meal, that standard body weight measures 70 kg, standard consumption rate is 225 meals, 52 meals, 12 meals, 6 meals, or no meals per year averaged out over 365.25 days. These combined statistics create an average gram per day consumption rate. The RfD, or exposure limit, for mercury is currently set at 0.1 µg/kg body weight/day. The calculation of fish consumption advisories for mercury back calculates to a fish tissue concentration where consumers can safely eat an amount to not exceed that exposure limit (Jim Stahl, pers. comm.).

Indiana works quite closely with all of the other Great Lake States. The Great Lake States tend to be the cutting edge leaders in fish consumption advisory risk communication. Indiana has a very comprehensive fish contaminants monitoring program that has been described as one of the leading monitoring programs in the nation.

7.1.1 Sources of Mercury

Much of the mercury found in aquatic ecosystems comes from atmospheric deposition via precipitation and dry deposition. Mercury is emitted to the atmosphere from coal combustion, waste incineration, steel mills, metal smelting, refining, and from mobile sources (Risch, 2007). Industrial and municipal discharges of wastewater and stormwater may introduce mercury directly into waterbodies. Natural processes that cause mercury emissions include wildfires, volcanoes, and geothermal sources (Risch, 2007).

Stormwater flowing over land may also pick up deposited mercury and transport it to waterbodies. Engstrom et al. (2007) found a direct link between human disturbance in watersheds, increased soil erosion rates, and elevated mercury loadings to Minnesota lakes.

Undisturbed forest soils contained higher concentrations of mercury than agricultural lands. Engstrom et al (2007) indicated that these differences were likely due to mercury being lost from agricultural areas due to runoff and soil erosion. The source of mercury to these watersheds was atmospheric deposition from local and regional sources.

Fish living in aquatic systems containing low concentrations of mercury are known to accumulate mercury over time. This bioaccumulation can eventually result in fish exceeding the reference dose for mercury, posing a health risk to humans and wildlife that consume the mercury-contaminated fish.

In a three-year study of mercury in precipitation in Indiana, normalized total mercury deposition measured in Bloomington was 259 ng/m²/inch of precipitation. The volume-weighted total mercury concentration in Bloomington was 10.3 ng/L of precipitation (Risch 2007). The concentrations in Bloomington were lower than those from three other sampling locations in Indiana (Indiana Dunes, Clifty Falls, and Roush Lake).

7.1.2 Recommendations

There is little that Bloomington can do to decrease the concentration of mercury in atmospheric deposition since this is a regional and even global phenomenon. However, every little bit can help. Society can reduce sources of mercury to the atmosphere by requiring technology to reduce mercury release from coal-fired power plants and other industrial sources, prohibiting household waste incineration, and proper disposal of household products containing mercury such as thermometers, switches and fluorescent light bulbs.

Loading of mercury to Griffy Lake from its watershed can be mitigated by policies and actions designed to prevent runoff and soil erosion. Specific areas where these activities can be enacted are discussed in further detail in the **Adjoining Property Influence Section**.

7.2 Bathymetric Survey Results

IDNR has not completed their bathymetric survey compilation and map generation. DNR anticipates developing a timeline for completion by March 30th. If the map is finalized prior to this report being finalized, it will be included in the final report.

7.3 Sedimentation Rate Determination

IDNR has not completed their bathymetric survey compilation and map generation. This determination is on hold until these results become available and/or the end of this project. At such time, an assessment will be completed as best is possible.

7.3.1 Recommendations

Sediment sampling data completed by Indiana University School of Public and Environmental Affairs in 2004 indicates that sediment is accumulating in Griffy Lake. This is not surprising as Griffy Lake is a reservoir located within a developed, urban area. As noted by Jones (2004), the sedimentation rate of Griffy Lake is relatively low; however, sedimentation is a problem within specific areas in the lake. Specifically, sediment deposition occurs at the mouth of Griffy Creek where water velocities slow as the creek enters the lake and at the causeway where the Headley Road bridge constricts water flow. In both of these areas, sediment deposition is occurring with accumulations estimated at 0.5 meters east of the causeway to less than 20 cm in the deepest water near the dam (Jones, 2004).

Based on this and observational assessments, a two-pronged approach should occur. First and foremost, efforts to reduce sediment loading to Griffy Lake should occur. As Griffy Lake is a

back-up drinking water source, efforts should be made to maintain as large of a pool volume as possible. Since sediment has already accumulated within the lake, dredging of accumulated material should be investigated as a future option.

A number of mechanisms exist for removing accumulated sediment from Griffy Lake. The three primary options include hydraulic dredging where accumulated sediment and water are pumped from the dredging location to a spoils basin. There, the spoils are allowed to dry with accumulated water running through a filter and returning to Griffy Lake. This is a feasible option for dredging east of the causeway if the boat ramp and parking lot were closed and used as a temporary staging area. Secondly, dredging using a backhoe or crane may be an option for specific areas along the causeway or in areas that are reachable via shore. As with the hydraulic dredging option, sediment would need to be transported to the parking lot, allowed to dry, and then be trucked off-site. Additionally, during lake drawdown for dam repairs, sediment removal may be possible with a combination of these options as more areas of the lake bottom will become accessible. None of the above options will be easily accomplished given the steep topography within and surrounding Griffy Lake. Dredging is estimated to cost a minimum of \$10,000 for equipment mobilization to the site and upwards of an additional \$35,000 per acre for sediment removal, placement, and/or hauling, as necessary. Long-term solutions involving placement of dredged materials, access to the lake, and funding must be addressed prior to any activities related to dredging being initiated. Additionally, permits are required from the IDNR, IDEM, and Army Corps of Engineers in order for dredging to occur within Griffy Lake.

7.4 Water Quality Assessment

Griffy Lake's water quality has been assessed regularly over the past 20 years. Most data were collected by the Indiana Clean Lakes Program, volunteer monitors through the ICLP, and Indiana University students as part of a Limnology class exercise. More recent sampling efforts include those by Aquatic Control, Inc. during completion of aquatic plant surveys as part of the effort to manage Griffy Lake's aquatic plant community. Table 7 details the water quality data collected within Griffy Lake's recent past, while all identified data are included in Appendix X.

Table 7. Summary of historic data for Griffy Lake.

Date	Secchi (ft)	% Oxid	Epi pH	TP (mg/L)	Chl a (µg/L)	ITSI Score	Source
7/1/91	13.5	66.7%	--	0.028	--	19	CLP, 1991
1994 mean	9.2	--	--	--	--	--	Volunteer Monitor
1995 summer mean	10.4	--	--	--	--	--	Volunteer Monitor
1995 fall mean	10.0	57.8%	7.9	0.024	14.5	--	IU-SPEA, 1995
1996 mean	14.2	--	--	--	--	--	Volunteer Monitor
1997 summer mean	14.1	--	--	--	--	--	Volunteer Monitor
1997 fall mean	7.9	70.4%	8.0	0.030	6.2	--	IU-SPEA, 1997
7/22/97	16.4	66.7%	8.19	0.062	0.9	7	CLP, 1997
1998 mean	9.5	--	--	0.360	5.2	--	Volunteer Monitor
1999 summer mean	16.2	--	--	0.040	1.413	--	Volunteer Monitor
1999 fall mean	15.6	88.9%	8.2	0.034	2.5	--	IU-SPEA, 1999
2000 mean	10.8	--	--	0.093	0.9	--	Volunteer Monitor
2001 mean	--	--	--	0.035	1.9	--	Volunteer Monitor
2002 mean	13.6	--	--	0.037	1.400	--	Volunteer Monitor
7/2/03	11.2	--	--	--	--	--	Volunteer Monitor
5/17/04	11.0	--	--	--	--	--	Kittaka, 2006

Date	Secchi (ft)	% Oxic	Epi pH	TP (mg/L)	Chl a (µg/L)	ITSI Score	Source
2004 mean	10.5	--	--	0.010	1.6	--	Volunteer Monitor
2005 average	8.0	--	--	0.029	2.5	--	Volunteer Monitor
2006 mean	8.3	--	--	--	--	--	Aquatic Control, 2007
6/6/07	10.1	--	--	0.029	1.8	--	Volunteer Monitor
8/1/07	10.0	--	--	--	--	--	Aquatic Control, 2008
8/20/07	8.2	66.7%	7.4	0.041	0.9	28	CLP, 2001
8/28/07	--	--	--	0.020	3.2	--	Volunteer Monitor

Note: Secchi=Secchi disk transparency, % oxic=percentage of the water column containing >1 mg/L dissolved oxygen, epi pH=epilimnetic pH or surface water pH; TP=total phosphorus, Chl a=chlorophyll a, ITSI=Indiana Trophic State Index

Based on the data presented in Table 7, water quality in Griffy Lake has remained stable over the past 17 years. Water clarity in Griffy Lake rates as relatively good for the region, and is better than most lakes in Indiana. Since 1991, Secchi disk transparency (a measure of water clarity) has ranged from 4.0 feet (X m) in April 2006 to 23.0 feet (X m) in September 1999. Data collected by a variety of organizations confirms that clarity has remained relatively stable at Griffy Lake over the past 40 years; however, the trend line indicated in Figure 51 suggests that water clarity may be declining slightly. (Note that poor water clarity (0 feet) is displayed at the top of the graph.) In actuality, the number of samples collected on an annual basis and the timeframe in which the samples are collected likely accounts for the water clarity differences observed early in the sample period compared to later in the period. Prior to 1999, water clarity measurements were taken throughout the growing season from April to October. Since 1999, the number of samples and the range of time in which the samples were collected declined. During the most recent years, only a few measurements of Griffy Lake's water clarity occurred. Additionally, these assessments occurred in mid-summer when water clarity is typically at its poorest. All of these factors combine to suggest a decline in water clarity based on the trend line; however, it is more likely that water clarity within Griffy Lake has changed little over the past 40 years.

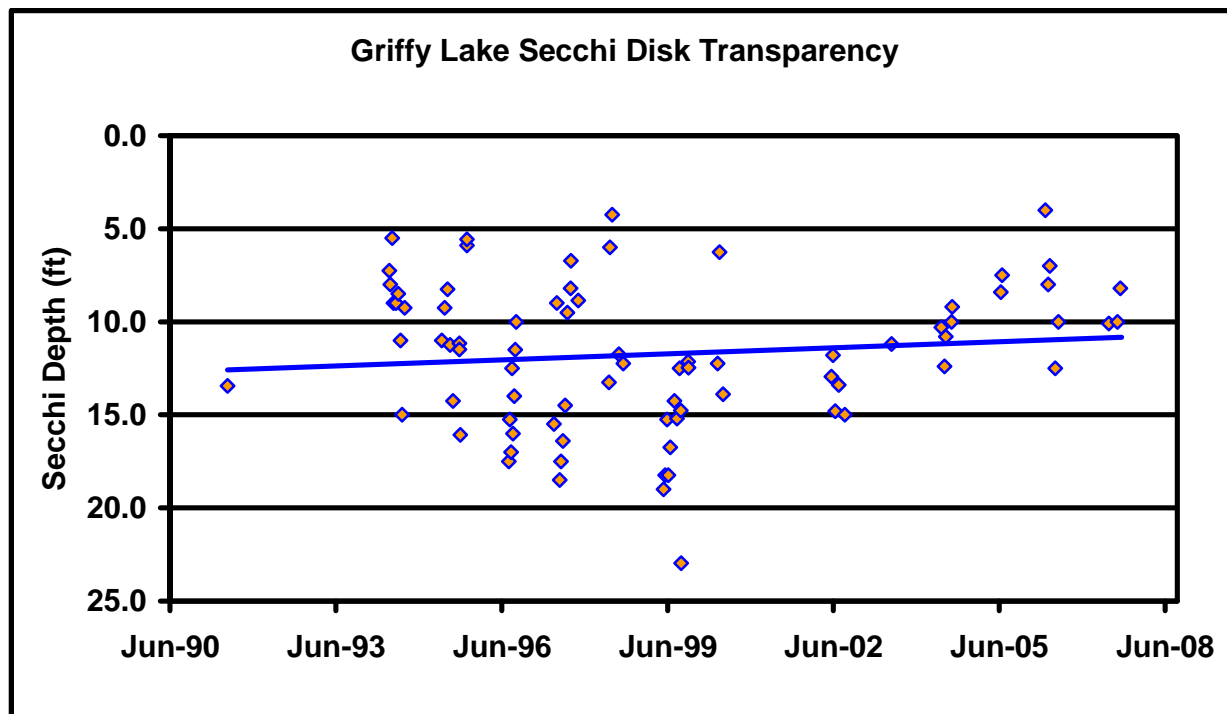


Figure 51. Historic Secchi disk transparency data for Griffy Lake.

Source: CLP, 1991, 1997, 1999; Volunteer monitors 1994-2007; Aquatic Control, 2005-2008.

Total phosphorus concentrations measured relatively low within Griffy Lake with all samples well below the median concentration (0.17 mg/L) observed in Indiana lakes. Total phosphorus concentrations ranged from 0.010 mg/L in 1998, 1999, and 2004 to 0.113 mg/L in 2000 (Figure 52). There is not an apparent trend in total phosphorus concentrations in Griffy Lake; however, concentrations suggest a slight improvement in water quality throughout the sample period (Figure 52). Overall, concentrations remain low within Griffy Lake but fluctuate throughout the sampling season. Similarly low dissolved phosphorus concentrations are present within Griffy Lake. Dissolved phosphorus concentrations typically measured more than an order of magnitude less than the dissolved phosphorus concentration found in Indiana lakes (0.12 mg/L). This suggests that most of the phosphorus present in Griffy Lake is the in the particulate form arriving in the lake attached to sediment. This form of phosphorus is generally considered to be unavailable to lake biota and therefore is not usable for plant and algae production.

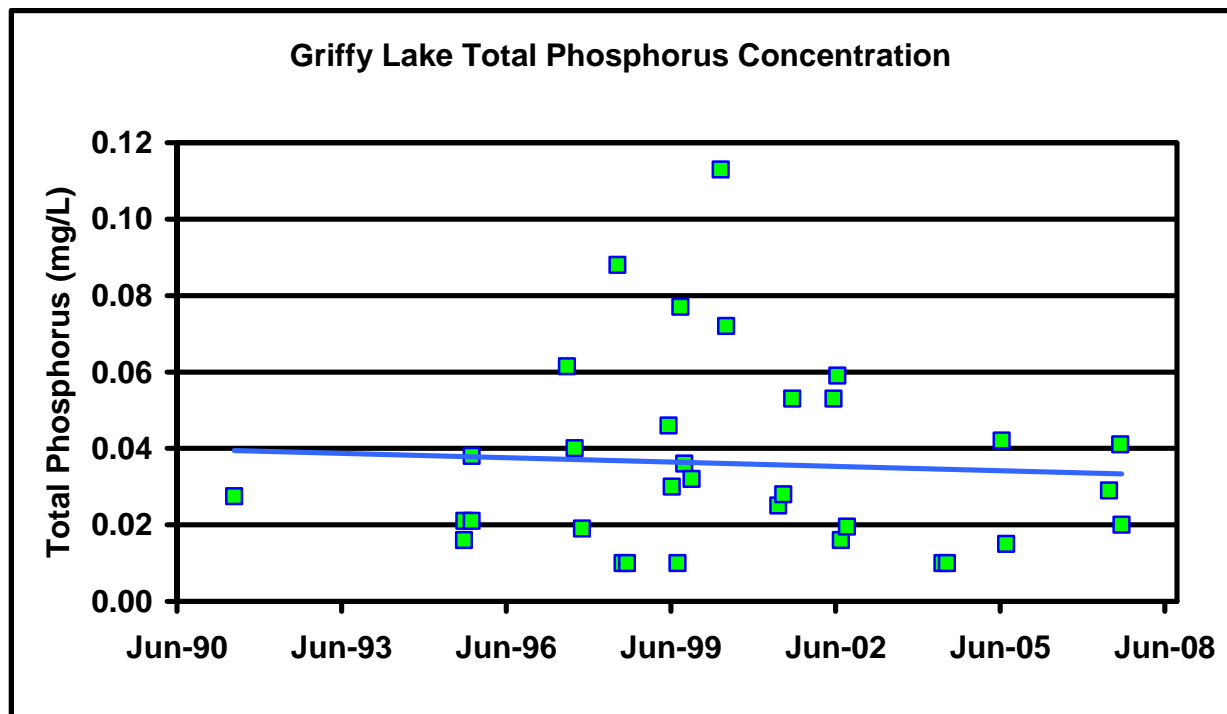


Figure 52. Historic total phosphorus concentrations measured in Pretty Lake.

Source: CLP, 1991, 1997, 1999; Volunteer monitors 1994-2007; Aquatic Control, 2005-2008.

The lake's algae (plankton) densities are relatively moderate as is expected given the lake's relatively low phosphorus concentrations. Nutrients (nitrogen and phosphorus) promote the growth of algae and/or rooted plant populations. Thus, lakes with high nutrient levels are expected to support dense algae and/or rooted plants and lakes with lower nutrient levels are anticipated to support less dense algae and/or rooted plant communities. Plankton densities are relatively low within Griffy Lake ranging from 4,647/L to 20,485/L. Overall, plankton density and total phosphorus concentrations were unrelated in that the highest plankton density does not coincide with the highest total phosphorus concentration measured in the lake. Conversely, the lowest plankton density does coincide with the lowest total phosphorus concentration (1991). These data suggest that something other than nutrients limit plankton production within Griffy Lake. Chlorophyll *a* concentrations further support this idea as chlorophyll *a* concentrations rarely reflect the variation in plankton densities or total phosphorus concentrations found in the lake (Table 7; Figure 53). Additionally, these chlorophyll *a* concentrations rarely exceeded the median concentration observed in Indiana lakes (12.9 µg/L).

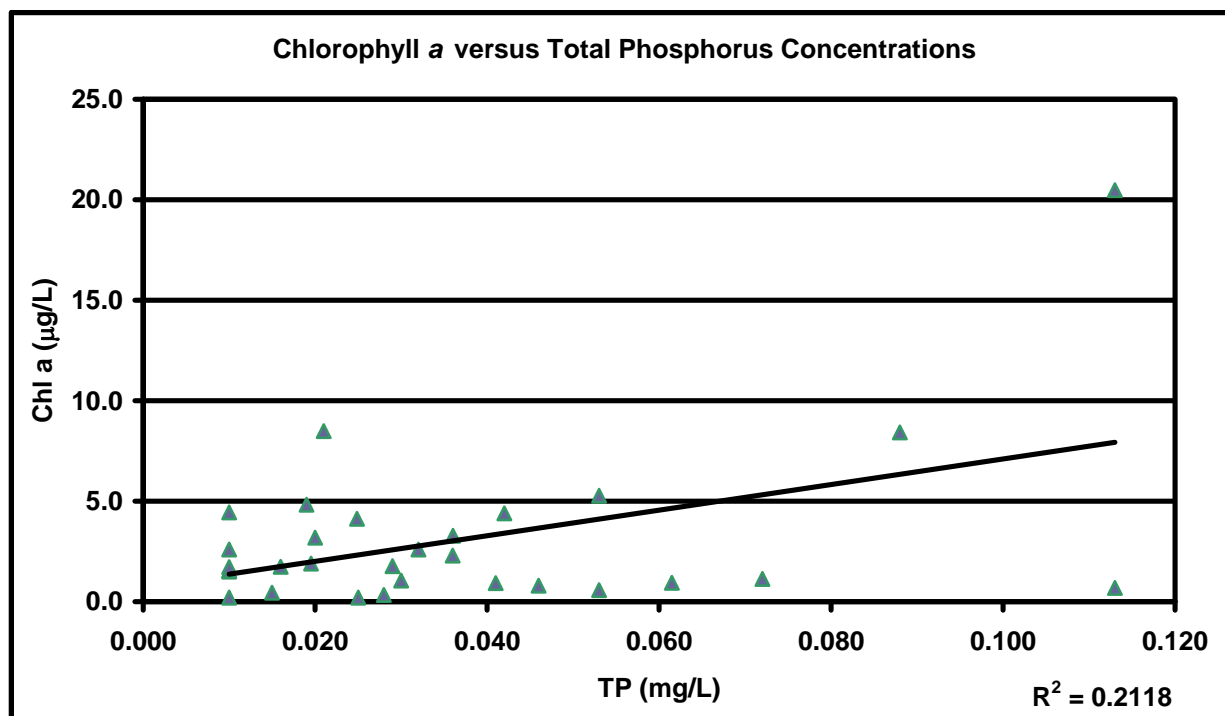


Figure 53. Total phosphorus and chlorophyll a concentrations measured in Griffy Lake, 1991 to 2007.

The lake's Indiana Trophic Score Index (ITSI) ranged from 7 in 1991 to 28 in 2001. These scores suggest that the lake is oligotrophic to mesotrophic which may under-represent Griffy Lake's true trophic status. Carlson analyzed summertime total phosphorus, chlorophyll a, and Secchi disk transparency data for numerous lakes and found statistically significant relationships among the three parameters. He developed mathematical equations for these relationships, and these relationships form the basis for the Carlson TSI. Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency, chlorophyll a, or total phosphorus. Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass. Using Carlson's index, a lake with a summertime Secchi disk depth of 1 meter (3.3 feet) would have a TSI of 60 points (located in line with the 1 meter or 3.3 feet). This lake would be in the eutrophic category. Because the index was constructed using relationships among transparency, chlorophyll a, and total phosphorus, a lake having a Secchi disk depth of 1 meter (3.3 feet) would also be expected to have 20 µg/L chlorophyll a and 48 µg/L total phosphorus.

For Griffy Lake during the most recent assessment (2001), Carlson's TSI scores using transparency and total phosphorus concentration are equal (TSI (SD) = 47 and TSI (TP) = 47). However, Carlson's TSI score for chlorophyll a concentration is much lower (TSI (chl a) = 30). When TSI (SD) = TSI (TP) > TSI (chl a), something other than phosphorus is limiting algae growth. Potential limiting factors include zooplankton grazing and/or nitrogen limitation. In the case of Griffy Lake, zooplankton grazing may affect the lake's algal community. (Further studies would be needed to confirm this.) Additionally, the lake's rooted plant community likely plays a role in limiting algae growth. Rooted plants have been shown to secrete alleopathic chemicals preventing algae growth. Again, more research (i.e. year round evaluation of the lake's temperature profile) is needed to determine if this is a factor in limiting algae production.

Additionally, it should be noted that when Carlson's Trophic State Index is used to assess Griffy Lake's transparency, algal density (chlorophyll *a* concentration), and total phosphorus concentration, data suggest that Griffy Lake's trophic status is poorer than that suggested by the ITSI. Carlson's TSI rates Griffy Lake as mesotrophic to slightly eutrophic during the most recent assessment.

7.4.1 Recommendations

At this time, City of Bloomington Utilities (CBU) maintains Griffy Lake as a back-up drinking water source. Maintenance as a back-up drinking water source should continue. Ideally, the community should strive to maintain the quality of Griffy Lake's water; however, watershed-based improvements could result in better than typical water quality in Griffy Lake. Based on this, efforts should be made to not only reduce the amount of sediment and nutrients flowing into Griffy Lake, but also to reduce the volume of water reaching the lake. As evidenced in Figures 54 and 55, Griffy Lake receives a large volume of water during typical storm events (greater than 1-inch of precipitation). In order to maintain and/or improve water quality within Griffy Lake, sediment stabilization and water retention efforts should be initiated. Specific examples of projects which could be implemented to reduce sediment and nutrient loading to Griffy Lake and to reduce the volume and velocity of water reaching the lake are identified in both the **Soil Erosion Survey Section** and in the **Adjoining Property Influences Section** of this report.



Figures 54 and 55. Docks adjacent to the boat ramp during typical conditions and during a 1.5-inch rain event, March 2008.

7.5 Aquatic Plant Community Assessment

7.5.1 Historic Aquatic Plant Community Control

Aquatic plant control efforts over the past five years targeted the eradication of Brazilian elodea (*Egeria densa*). Griffy Lake is the sole public waterbody in Indiana where Brazilian elodea has been identified. Due to its invasive nature, propensity to crowd out native aquatic plant species, and ability to commandeer a waterbody, the IDNR, City of Bloomington Utilities, and Bloomington Parks and Recreation deemed that eradication of this species was of utmost importance. Brazilian elodea was first identified in Griffy Lake in 2004 and Aquatic Control, Inc. completed an initial plant management plan for Griffy Lake targeting the eradication of this species. Aquatic Control identified Brazilian elodea at near 32% of sample sites within Griffy Lake and also identified two other exotic invasive species in Griffy Lake: Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). Surveys completed by Aquatic Control and IDNR biologists in 2005 indicated that Brazilian elodea continued to

spread throughout the lake (Aquatic Control, 2008). Based on these findings, the IDNR funded a whole-lake treatment in 2006 with the end goal of eradication of Brazilian elodea from Griffy Lake. No rooted Brazilian elodea was identified in 2006; however, due to the identification of floating stems, a whole-lake treatment was completed in 2007. Since this treatment, no additional Brazilian elodea has been discovered in Griffy Lake; however, this does not indicate that Brazilian elodea was eradicated from Griffy Lake (Aquatic Control, 2008).

As a by-product of these high-dose, whole-lake treatment efforts, many of the aquatic plant species historically present in Griffy Lake were not observed in 2007 (Aquatic Control, 2008). During Aquatic Control's 2007 survey efforts, only musk grass (*Chara*) was observed within the lake. During JFNew's community mapping effort, horned pondweed, Eurasian watermilfoil, variable-leaf watermilfoil, and curly-leaf pondweed were identified from the shoreline. However, as a complete survey of the lake's plant community was not completed, it is likely that additional aquatic plant species were present within the lake but were not identified during this property-wide survey. These data suggest that the seed bank is sufficient within Griffy Lake for the aquatic plant community to return on its own volition. IDNR biologists concur with this and anticipate that the native plant seed bank will provide adequate density and diversity within Griffy Lake during the 2008 growing season (Doug Keller, personal communication).

Results from other lakes undergoing whole-lake sonar treatments in the past support this premise. Survey efforts in Burr Pond (Vermont) indicate that native species density and diversity declined within the first year following whole-lake sonar treatment (Eichler and Boylen, 2007). Two years following treatment, more than 25% of the native species returned to densities similar to pre-treatment conditions. Native species diversity continued to increase within Burr Pond following whole-lake treatment with native plant density and diversity reaching pre-treatment levels six years following treatment (Eichler and Boylen, 2007). Treatment and monitoring efforts in Lake Horton (Vermont) indicate similar but mixed results. Overall, the native plant community returned to pre-treatment density and diversity levels; however, native plant diversity in shallow areas (less than 2 meters in depth) remains lower than pre-treatment densities even five years after treatment. Similar conditions and conclusions are also drawn when data from Lake St. Catherine, Little Lake, and Lilly Pond (New York) are observed. Four years after treatment, exotic species biomass decreased in all three lakes, while plant cover and plant biomass remained constant and/or increased within the lakes (ACT, 2007). Based on these examples, transplanting of native species into Griffy Lake is not necessary at this time as the native seed bank is likely able to supply sufficient density and diversity of native species to revegetate Griffy Lake without human intervention.

7.5.2 Future Aquatic Plant Control Efforts

As previously stated, the ultimate goal of the previous year's aquatic plant community control efforts was the eradication of Brazilian elodea. Future efforts should target the continued observation for this species and other exotic, invasive species like Eurasian watermilfoil and curly-leaf pondweed, both of which have been identified in Griffy Lake in the past. Based on CBU's goal to maintain Griffy Lake as a back-up drinking water supply, it is necessary to maintain a balanced aquatic plant community that does not prevent accessibility to open water and/or prevent any future water withdrawals due to pipe clogging or overgrowth of aquatic plants. To meet the first goal, three aquatic plant surveys are scheduled to occur during 2008 in an effort to observe changes in the lake's aquatic plant community. During the most recent survey, which occurred April 9, 2008, curly-leaf pondweed was identified within Griffy Lake. Curly-leaf pondweed is like other exotic, invasive species in that it takes advantage of unique qualities to increase its growth and viability. This includes growing earlier than most other species, especially native species, and over summering and over wintering in the form of

turions, which can survive in the lake's sediment for prolonged periods of time. In an effort to remove this species, 12 acres of curly-leaf pondweed treatment were recommended by Aquatic Control (Figure 56). Treatment will occur this spring in the first of a (minimum) three-year program targeted at reducing the growth and, if possible, eradicating curly-leaf pondweed from Griffy Lake.

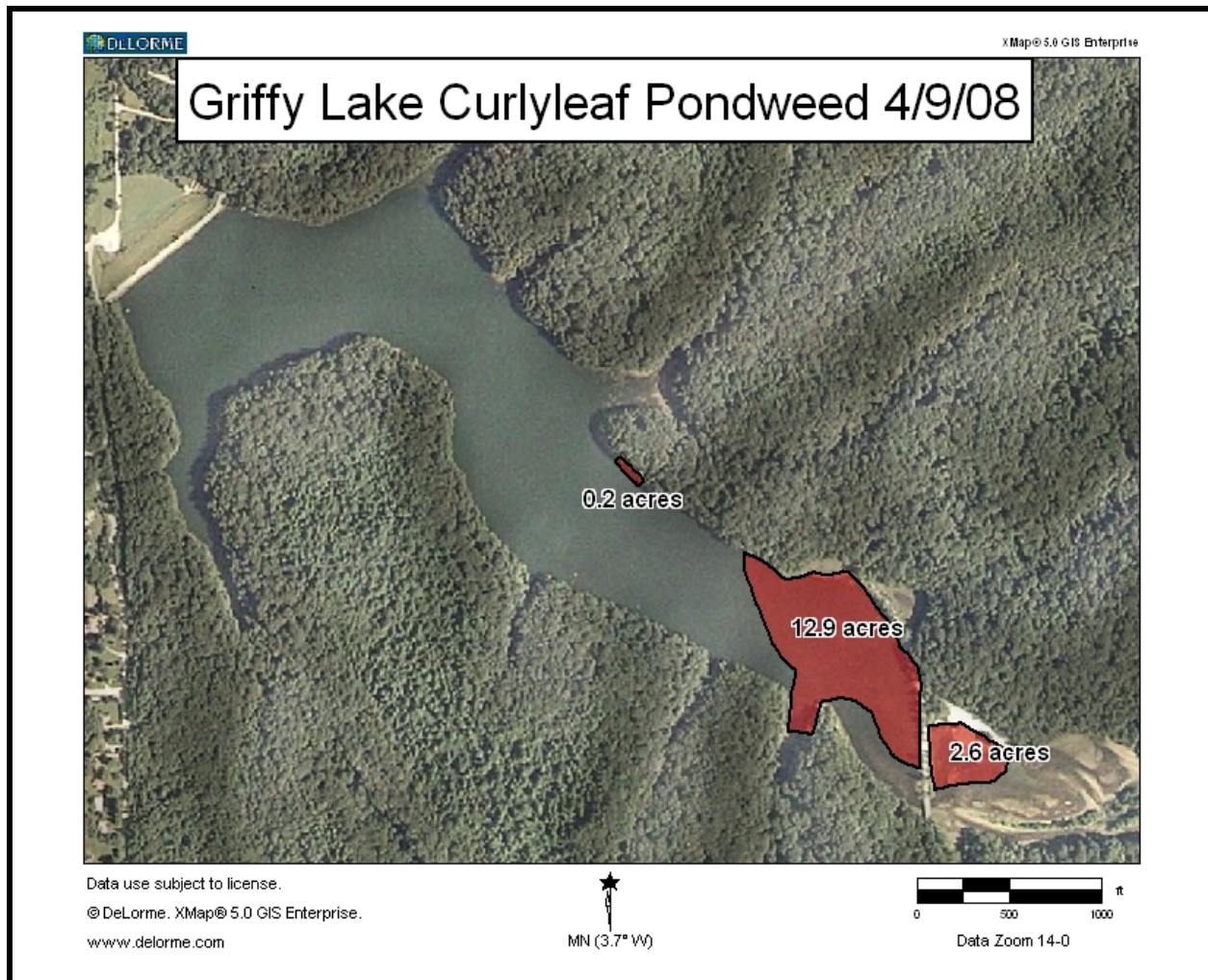


Figure 56. Areas of Griffy Lake targeted for curly-leaf pondweed treatment in 2008.

Source: Aquatic Control, Inc.

7.5.3 Aquatic Plant Control Options

At this time, chemical control of the aquatic plant community is the most well-proven treatment option to control the exotic, invasive species present in Griffy Lake. In the IDNR's opinion, chemical treatment was the only option available to provide the highest likelihood of eradicating Brazilian elodea from Griffy Lake thereby preventing its spread to other lakes within Indiana. There are other options for the long-term control of the other exotic, invasive species present in Griffy Lake. A number of these options are detailed in the 2007 Aquatic Vegetation Management Plan Update completed by Aquatic Control (2008). Some potential options are discussed below along with their likelihood for success within Griffy Lake.

No Action

As detailed by Aquatic Control, no action is typically an option to control exotic, invasive plants in most lakes in Indiana; however, this has not been and will not really be an option in Griffy Lake in the future. To date, the IDNR spent more than \$150,000 to eradicate Brazilian elodea from Griffy Lake. Because Griffy Lake is a back-up drinking water supply and the sole lake in Indiana where Brazilian elodea has been observed, lack of treatment of this threat was not and will not be an option in the future. However, with regards to the two other species, Eurasian watermilfoil and curly-leaf pondweed, no action could be an option if the lake were not to remain a back-up drinking water supply. Based on CBU's desires, continued Eurasian watermilfoil and curly-leaf pondweed population control efforts in Griffy Lake must be continued.

Prevent Exotic Species Introduction

The most important effort that should occur in the community in the future is an education effort targeted at the prevention of the spread of exotic species. All of the exotic species previously identified within Griffy Lake are prevalent within the aquarium trade and/or are present in many lakes throughout the state. The spread of these species occurs due to wildlife and human factors, namely boat trailers and aquarium dumping. All individuals should be educated on the long-term risks of transporting aquatic plants in any fashion from one location to another. Additionally, Bloomington Parks and Recreation should search upstream drainages for the presence of exotic species in order to prevent their spread to Griffy Lake.

Water Level Manipulation

As detailed in subsequent sections, the CBU will likely need to draw Griffy Lake down in order to repair structures associated with the Griffy Lake high-hazard dam. If timed correctly, this drawdown could be coupled with an aquatic plant control effort to reduce the density of exotic species.

Nutrient Reduction

Second only to education in the effort to control exotic, aquatic plants is an effort to reduce nutrient and sediment loading to Griffy Lake. As previously noted, Griffy Lake's nutrient levels are relatively low; however, sufficient nutrients are present to allow for aquatic plant growth. If watershed and shoreline efforts are implemented to reduce the flow of sediment and nutrients to Griffy Lake, then the lake should be a sustainable resource as both a back-up drinking water supply and a source of low-impact recreational enjoyment for the community for years to come.

7.5.4 Recommendations

Long-term aquatic plant control efforts are a necessity within Griffy Lake. Specific recommendations are as follows:

- Implement an education program to educate area residents and university students on the impacts of exotic, invasive aquatic species to Griffy Lake and other waterbodies.
- Continue observation efforts for Brazilian elodea and implement immediate control actions as specified in the 2007 Griffy Lake Aquatic Vegetation Management Plan Update.
- Implement watershed-based actions to reduce sediment and nutrient loading to Griffy Lake.
- Investigate opportunities to couple water level manipulation opportunities (lake drawdown) to control aquatic plants with efforts to repair the existing high hazard dam.

7.6 Fish Community Assessment

The Griffy Lake fishery is managed by the Indiana Department of Natural Resources. Due to Griffy Lake's proximity to Bloomington, it is a popular fishing destination. As detailed in the **Facilities and Infrastructure Assessment Section**, boat rental and boat ramp usage has increased over the last few years. This is readily apparent when comparing pre- and post-ramp closing for Brazilian elodea treatment. Local residents indicate that the fishery may feel the pressure of the high density of fishing that occurs throughout the lake and along the shoreline. During the spring open house, individuals suggested that the lake may be over-fished (personal communication). As a fisheries assessment component was not part of this master plan update, reliance on available historic data is the best way to assess the condition of the fish community within Griffy Lake.

7.6.1 Historic Assessments

The DNR surveyed the fish community in 1982, 1992, 1998, and most recently in 2004. During the 1982 assessment, carp dominated the Griffy Lake fishery. The DNR opted to conduct a fish renovation following this assessment in hopes of rebalancing the fish community to create an active game fishery. Subsequent surveys conducted in 1992 indicated that the fishery was in good condition and that no management changes were required. This management program includes a 14-inch size limit on largemouth bass and biennial stocking of channel catfish at a rate of 17 fish per acre (Kittaka, 2006).

A total of 615 fish were collected during the most recent assessment, which occurred May 17 and 18, 2004. Bluegill were the most abundant species accounting for 58% of the fish community. Largemouth bass (16%) and redear (13%) were also prevalent during this assessment. Warmouth, longear sunfish, white sucker, black crappie, channel catfish, yellow bullhead, common carp, and hybrid sunfish were also collected during the assessment. Overall, bluegill of harvestable size (6 inches or greater) comprised 17% of the community. Additionally, bluegill growth rates were below average for bluegill under five years of age, while growth rates were above normal for bluegill over five years of age. The largemouth bass community rated similarly with 17% of collected largemouth bass measuring at or above legal size (17 inches). The DNR rated age 1 and 2 largemouth bass growth rates as below average, while age 3 and 4 largemouth bass rated as slightly below average (Kittaka, 2006).

7.6.2 Recommendations

Based on these data, Griffy Lake contains a quality fishery. However, fisheries surveys have not been completed since the lake was re-opened following treatment for Brazilian elodea; therefore, it is not possible to determine whether the public's concerns of the lake be 'over-fished' are in fact reality. It is necessary that Bloomington Parks and Recreation consult with the DNR in order for a post-Brazilian elodea treatment fisheries assessment to occur.

7.7 Water Level Management Assessment

As part of the Griffy Reservoir Dam Restoration Plan, the City of Bloomington Utilities Service Board hired ms consultants, inc. to complete a dam restoration plan, develop an emergency action plan, and identify any water level management issues associated with the dam structure. The restoration and emergency action plans are currently in their development stage. The improvement needs identified by ms consultants, inc. (Kratofil, 2008) include:

- Control of seepage through the earthen dam embankment;
- Removal of debris and vegetation overgrowth around the dam;
- Repairs to the 66-inch diameter drawdown conduit;
- Outlet channel clearing, regrading, and stabilization;
- Repairs to the inboard concrete slope protection; and

- Security and signage improvements.

The initial phase of the restoration plans target three main items: routine maintenance including vegetation and debris removal, fence removal and replacement, sign posting, and joint and crack repair. Long-term restoration plans will include outlet channel work and water drawdown conduit repairs. These items will require water level draw downs to occur, which could impact the biota within Griffy Lake. Finally, ms consultants, inc. will be developing an emergency action plan which will identify downstream areas which could be impacted due to flooding if the dam were to breach or fail and establish a protocol for information distribution and action if a breach or failure were to occur.

7.7.1 Recommendations

The items associated with the Griffy Reservoir Dam Restoration project should be implemented by the City of Bloomington. Coordination should occur between the City, the Indiana Department of Environmental Management, who is charged with water control structure maintenance, and the Indiana Department of Natural Resources, who is charged with maintenance of the biotic community within Griffy Lake. This effort should ensure that structural repairs are completed in compliance with IDEM requirements while causing minimal negative impacts to the lake's biotic community. Additionally, the City of Bloomington should take this opportunity to install a water level gauge so that water levels can be routinely monitored. Finally, the IDEM, DNR, and City of Bloomington should work together to develop a water manipulation strategy which could be used to target exotic, invasive aquatic plant species control efforts.

8.0 USER GROUP AND PROPERTY USE PROFILES

The visitor survey was conducted at Griffy Lake Nature Preserve in the summer and fall of 2007 and the winter and spring of 2008. The purpose of the survey was to learn about user patterns, motivations, preferences, perceptions, expectations and needs of visitors to the Griffy Lake Nature Preserve. The results gathered from the survey serve as a basis for determining facilities needs, management priorities and recreational needs.

8.0.1 Survey Design

Sample Size and Plan

A systematic sampling procedure used a predetermined interval chosen to ensure that 5 surveys per hour would be distributed to every visitor to the park over 16 years of age. The goal was to intercept 600 visitors over the 4 month period. The parking lot by the boathouse and the parking lot by the dog area/dam served as sampling locations. Approximately 80% of the intercepts occurred at the boathouse lot, while the remaining 20% occurred at the dam parking lot. Two self-serve survey sign-up sites were also available at the Lanam Road entrance and at the Meadowood trailhead. Sampling locations were selected based on visitor data and advice from Bloomington Parks and Recreation.

Questionnaire Design

The survey was developed and designed by project staff with input from the Bloomington Parks and Recreation staff. Appendix X contains the survey.

Survey Procedure

A random sample of visitors was chosen project staff during 4 one-month long intervals (one per season) at two locations in the preserve. To achieve the goal of intercepting 600 visitors over the 4 month period, there were 60 two-hour shifts during which visitors were intercepted. Based on visitor data, six shifts occurred during the month of January 2008, 24 shifts during the month